

## Abstract

---

Geosynthetics are used in conjunction with soil/particulate materials to serve various functions like reinforcement, drainage, filtration and containment. The shear behavior of soil-geosynthetic interfaces hugely depends upon on the morphological properties of particulate materials and surface characteristics of geosynthetics. However, many researchers have ignored the effects of morphology, owing to the difficulty in finding the morphological characteristics of sand particles. Few of them used visual, manual and imaged based quantifications, which are not very effective. Also, the effects of particle size and morphology are often combined and the individual effect of these parameters cannot be easily separated. In addition to this, there are very few studies which have given importance to quantitative understanding of surface features/roughness of geosynthetics and almost all of them are limited to 2D surface measurements.

The objective of this thesis is to understand the interface shear mechanisms of sand-geosynthetic systems through modified large interface direct shear tests coupled with morphological characterization of sands using advanced image based and optical techniques and surface topographical analysis of geosynthetics using 3D interferometry. The individual effects of particle size and morphology on interface shear mechanism are investigated by carefully selecting the sands having specific size fractions and different morphological characteristics.

A new computational method based on image analysis is proposed in this study to quantify the morphology of sands (roundness, sphericity and roughness) more accurately by writing several algorithms and implementing them in MATLAB. The roundness and sphericity of sand particles in this method are quantified as per Wadell (1932) and Krumbein and Sloss (1963) respectively and the root mean square roughness is used as a measure of surface roughness. Out of total four sands, namely coarse sand (CS), medium sand (MS), fine sand (FS) and angular coarse sand (ACS) used in this study, CS, MS and FS have similar morphology and different particle sizes, whereas

CS and ACS have same size and dissimilar morphology. The effects of size and morphology of sand particles on the interface shear behavior are examined through direct shear tests on dilative and non-dilative interfaces. After examining the boundary effects on deformation patterns analyzed using shear bands in conventional, fixed box and symmetric interface direct shear tests, symmetric interface direct shear test is observed to show uniformity in stresses and deformations across the shear box and hence the same is adopted in this thesis. Test results revealed that the peak interface friction and dilation angles in case of dilative interfaces are hugely dependent upon the interlocking between the sand particles and the asperities of geosynthetic material, which in turn depend on the relative size of sand particles and asperities. Highest interface shear strength is observed when the asperity size of the geosynthetic material matches with the mean particle size of sand, which is also manifested in terms of highest shear band thickness.

Direct shear tests on non-dilative interfaces (sand-smooth geomembrane) revealed that interface friction angle depends on the number of effective contacts rather than the particle size. Morphology of sands is found to have major influence on the interface shear strength among all the parameters investigated. Results from interface shear tests are examined in the light of topographical analysis of sand particles and shear induced surface changes in geomembrane. Possible shearing mechanisms at the interface and the influence of particle size, morphology and normal stress on sliding or plowing are brought out from 3D surface roughness measurements using 3D optical profilometer. The stress-shear displacement response of sand-geomembrane interfaces are correlated to the surface changes on sheared geomembranes through visual observations and roughness quantifications. Medium sand used in this study could make more number of effective contacts with deeper grooves, resulting in highest interface friction. The number of grooves are less in case of coarse sand and the depth of grooves is less in case of fine sand, resulting in lesser interface friction for these two sands compared to medium sand, supporting the results of interface shear tests.